Appl. No. 09/828,268
Reply to Office Action of January 30, 2004

Docket No. MGH-005AUS

Amendments to the Claims:

This listing of the claims will replace all prior versions, and listings, of the claims in the application:

1   1. (Original) A system for performing a virtual colonoscopy comprising:

2   (a)   a digital image generating system;

3   (b)   a storage device, coupled to said digital image generating system, said storage device for

4   storing digital images; and

5   (c)   a digital bowel subtraction processor coupled to receive images of a colon from said

6   storage device, said digital bowel subtraction processor for processing the received digital

7   images of the colon to digitally remove the contents of the colon from the image.

1   2. (Currently Amended) The system of Claim 1 further comprising:

2   an automated polyp detection processor coupled to receive images of a colon from said

3   storage device, said automated polyp detection processor for processing the received digital

4   images of the colon to detect polyps in the colon image.

1   3. (Currently Amended) The system of Claim 2~~1~~ wherein said automated polyp detection

2   processor processes images from which bowel contents have been removed by said digital bowel

3   subtraction processor.

1   4. (Original) The system of Claim 1 wherein said digital bowel subtraction processor

2   corresponds to a raster digital bowel subtraction processor.

1   5. (Original) The system of Claim 4 wherein said raster digital bowel subtraction processor

2   comprises:

3   a threshold circuit for assessing whether absolute threshold values have been crossed and

4   the ratio at which they have been crossed;

5   an analysis kernal to scan across images and apply threshold values in a predetermined

6   logic sequence;

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7   means for selecting a starting pixel;

8   means for selecting a direction to apply a threshold;

9   a threshold application means; and

10   a pixel reset means.

1   6. (Original) The system of Claim 1 wherein said digital bowel subtraction processor

2   corresponds to a gradient processor digital bowel subtraction processor.

1   7. (Original) The system of Claim 6 wherein said gradient processor digital bowel subtraction

2   processor comprises:

3   a threshold circuit for defining a soft tissue threshold value, an air threshold value and a

4   bowel threshold value;

5   a mask processor for marking elements above the bone threshold value;

6   a gradient processor for applying a air and bowel threshold values to appropriate regions

7   wherein said gradient processor forms a first mask to capture a first shoulder region in a region

8   corresponding to a transition between air and bowel;

9   a dilation processor for identifying a second shoulder region in the region corresponding

10   to a transition between air and bowel;

11   a subtractor for subtracting the combined masks from the gradient processor to leave a

12   desired image.

1   8. (Original) The system of Claim 2 wherein said automated polyp detection processor

2   comprises:

3   a segmentor to extract pixels in a region which includes a boundary between soft tissue

4   and air in the colon;

5   a rolling ball processor; and

6   a vector processor for computing a ratio along a travel path and comparing the travel path

7   to a threshold value.

1   9. (Original) The system of Claim 2 wherein said automated polyp detection processor

2   comprises:

3   a convolution processor for performing a convolution between a test polyp and a region

4   under test, to indicates the similarities between the region under test and the test polyp.

1   10. (Original) Thy system of Claim 9 wherein said convolution processor generates a

2   correlation matrix and wherein the convolution polyp detector further comprises a filter to

3   identify portions of the region under test which have relatively high correlation values.

1   11. (Original) The system of Claim 2 wherein said automated polyp detection processor

2   comprises a distance processor for aligning a distance template over the image and for

3   computing a plurality of distance values, each of the plurality of distance values corresponding to

4   a distance between a selected point on the distance template and a point on a bowel perimeter

5   with each of the plurality of distance values computed using a different point on the bowel

6   perimeter.

1   12. (Original) The system of Claim 11 wherein said automated polyp detection processor

2   further comprises a comparison circuit for comparing each of the plurality of distance values.

1   13. (Original) The system of Claim 12 wherein said comparison circuit includes means for

2   comparing each of the plurality of distance values by subtracting the values to provide a relative

3   distance value.

1   14. (Original) The system of Claim 11 wherein said automated polyp detection processor

2   further comprises a segmentor to extract pixels from the image to provide a region which

3   includes a boundary between soft tissue and air in the colon and wherein said distance processor

4   for aligns the distance template over the region provided by said segmentor.

1   15. (Original) The system of Claim 1 further comprising:

2   a detection system coupled to said digital bowel subtraction processor for detecting, in

3   the digital images of the colon having contents digitally removed therefrom, regions having one

4   or more characteristics similar to the characteristics of a polyp;

5   an indicator system for indicating on the images those regions detected by said detection

6   system

Claims 16-41 are cancelled.

Please add the following new claims.

1   42. (New) The system of Claim 1 further comprising a mucosa insertion processor for

2   providing a mucosa layer.

1   43. (New) The system of Claim 42 wherein said mucosa insertion processor comprises:

2   a gradient processor for applying a gradient operator to an image from which bowel

3   contents have been digitally extracted to identify pixels corresponding to a boundary between

4   bowel wall and non-bowel wall regions in the image; and

5   a smoothing processor for smoothing the boundary over a predetermined width along the

6   boundary.

1   44. (New) The system of Claim 43 wherein said smoothing processor comprises a filter which

2   filters the pixels which form the boundary.

1   45. (New) The system of Claim 44 wherein said filter is provided having a constrained

2   Gaussian filter characteristic.

1   46. (New) The system of Claim 45 wherein the predetermined width corresponds to one of:

2   a width of ten pixels;

3   a width in the range of two to five pixels; and

4   a width of three pixels.

1   47. (New) The system of Claim 1 further comprising a contrast agent adapted for ingestion by a

2   patient prior said digital image generating system generating one or more bowel images of the

3   patient.

1   48. (New) The system of Claim 42 wherein said digital bowel subtraction processor comprises:

2   a threshold circuit for applying a threshold function to the image of the colon; and

3   a gradient analyzer for performing a gradient analysis of the image of the colon to define

4   a first region corresponding to a wall region and a second region corresponding to a bowel

5   contents region.

1   49. (New) The system of Claim 6 wherein said gradient processor digital bowel subtraction

2   processor comprises:

3   a transition region identifier for identifying a portion of an image corresponding to an

4   image transition region having a first portion which corresponds to bowel contents, a second

5   portion which corresponds to bowel wall and a third portion disposed between the first and

6   second portions which corresponds to a transition between the bowel contents and the bowel

7   wall;

8   a shoulder region identifier for identifying first and second shoulder regions in the image

9   transition region;

10   means for dilating a boundary of the first shoulder region by applying a first threshold

11   function to the bowel image;

12   a gradient processor for applying a gradient to the bowel image to define a first region

13   corresponding to a wall region and a second region corresponding to a bowel contents region;

14   and

15   means for digitally removing the second region from the bowel image.

1   50. (New) The system of Claim 49 wherein said a shoulder region identifier comprises:

2   means for dilating pixels around a portion of the image transition region corresponding to

3   the second shoulder region;

4   a comparator for comparing each of the pixel values to a gradient threshold value;

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5   means, responsive to a pixel value being less than the gradient threshold value, for setting

6   that pixel value equal to a first predetermined value corresponding to a first one of a contents

7   region and a wall region; and

8   means, responsive to a pixel value being greater than the gradient threshold value, for

9   setting that pixel value equal to a second predetermined value corresponding to a second one of

10   the contents region and the wall region.

1   51. (New) The system of Claim 42 wherein said digital bowel subtraction processor comprises:

2   a pixel analysis map processor for generating a first pixel analysis map (PAM) from the

3   image;

4   means for stepping the first PAM across the image in a raster pattern;

5   means for locating an air region in the image by examining a predetermined set of

6   elements defined by the PAM;

7   means for searching an area around the air element to locate a bowel region adjacent the

8   air region; and

9   means for subtracting the bowel contents from the image.

1   52. (New) The system of Claim 1 further comprising:

2   means for representing an image of the colon by an array of pixels; and

3   means for selecting pixels in the image which represent bowel contents wherein said

4   means for selecting pixels comprises:

5   means for forming a pixel analysis map comprising an array of pixels, with

6   predetermined ones of the pixels in the map having a spatial relationship and a

7   predetermined threshold value;

8   means for applying the pixel analysis map to the image;

9   a comparison processor for comparing the values of the predetermined ones of the

10   pixels in the pixel analysis map to pixels in the image and indicating whether the

11   corresponding pixel in the image represents one of bowel contents or bowel wall; and

12   means for setting values of pixels in the image corresponding to bowel contents to

13   one of a pixel value corresponding to air and a pixel value corresponding to a bowel.

1   53. (New) The system of Claim 52 wherein said pixel analysis map processor comprises:

2   means for defining a plurality of central pixels at the center of the pixel analysis map;

3   means for defining a plurality of boundary pixels disposed about the plurality of central

4   pixels; and

5   means for defining a plurality of outer boundary pixels disposed about the plurality of

6   boundary.

1   54. (New) The system of Claim 53 wherein said comparison processor comprises:

2   means for selecting a first pixel of the plurality of central pixels;

3   means for computing a difference value between a pixel in the image which is in a

4   position adjacent to the position of the first pixel and an outer boundary pixel proximate the first

5   pixel; and

6   means, responsive to the difference value being above a gradient threshold, for setting the

7   values of all pixels between the first pixel and the outer boundary pixel to a predetermined value.

1   55. (New) The system of Claim 54 wherein the predetermined value corresponds to one of an

2   air value and a bowel value.

1   56. (New) The system of Claim 2 wherein said automated polyp detection processor comprises:

2   means for obtaining a test structure template from a first CT image;

3   means for selecting a portion of a second CT image;

4   means for performing a convolution between the test structure template and the selected

5   portion of the second CT image to produce a correlation matrix; and

6   means for identifying regions in the second image having values with a high correlation

7   to characteristics of a polyp.

1   57. (New) The system of Claim 56 wherein said means for obtaining a test structure template

2   comprises;

3   means for obtaining a first CT image which includes a structure of the type to be

4   detected; and

5   means for excising the structure from the CT image to provide the test structure.

1   58. (New) The system of Claim 58 wherein said means for identifying regions in the second

2   image comprises:

3   a filter for filtering values which are below a predetermined correlation threshold value;

4   and

5   means for designating a region of an image as having a likelihood of containing a

6   structure with a shape which is similar to the shape of the test structure;

1   59. (New) The method of Claim 57 wherein the test structure template corresponds to a polyp

2   template and the structure of the type to be detected in the first CT image corresponds to a polyp.

1   60. (New) The system of Claim 2 wherein said automated polyp detection processor

2   comprises::

3   means for moving a test element along a boundary of a bowel;

4   means for tracking a path defined by the movement of the test element;

5   means for detecting changes in direction of the test element in the path;

6   means for classifying bowel features based upon the path of the test element and the

7   changes in direction of the test element.

1   61. (New) The system of Claim 60 wherein said means for detecting changes in direction of the

2   test element in the path comprises:

3   means for computing changes in slope of the path defined by the test element;

4   means for marking a point at each location at which the direction of the slope of the path

5   means for changes; computing distances between each of the marked points; and

6   means for computing a ratio value using each of the distances.

1   62. (New) The system of Claim 60 wherein said means for classifying bowel features comprises

2   means for identifying bowel features using the ratio value computed by said means for

3   computing a ratio value.

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1　63. (New) The system of Claim 61 wherein the test element is provided having a circular shape;
2　and a spherical shape.

1　64. (New) A system of Claim 2 wherein said automated polyp detection processor comprises:
2　　　　means for applying a template to a region of an image which contains a bowel perimeter;
3　　　　means for computing a plurality of distances between the template and the bowel
4　perimeter, each of the plurality of distances corresponding to a distance from at least one point
5　on the template to one of a plurality of points on the bowel perimeter; and
6　　　　means for determining whether the distances are equal.

1　65. (New) The system of Claim 64 further comprising means for identifying the image region
2　as containing a structure having a shape which is similar to the shape of the template in response
3　to the distances being equal.

1　66. (New) The system of claim 64 wherein applying a template to a bowel perimeter comprises:
2　means for segmenting a bowel image to produce to an image from which pixels which do not
3　form the bowel perimeter have been filtered.

1　67. (New) The system of claim 64 wherein said means for computing a plurality of distances
2　between the template and the bowel perimeter comprises means for computing the distances
3　between points on a perimeter of the template and points on the perimeter of the bowel.

1　68. (New) The system of Claim 64 wherein said means for determining whether the distances
2　are equal comprises means for computing a standard deviation between the distances.